Project description

# Motivation for project proposal

Themes such as sustainability and the green transition have become a central part of political and economic discussions in Denmark. The interest of both politicians and ordinary Danes in these issues has been steadily increasing over the past decades, as could be observed in the recent election campaign, where issues such as climate, sustainability and the green transition were decisive for where Danes placed their vote. The signing of the Paris Agreement in 2015 marked a clear desire on the part of politicians for action in the climate field. A total of 196 countries, including Denmark, set a target of reducing greenhouse gas emissions by 40% compared to 1990 levels by 2030. Following the agreement, almost all countries presented their own national climate plans in the spring of 2016. As a further step in Denmark, the government passed a climate law in 2020 that called for a 70% reduction in greenhouse gases by 2030, compared to 1990 emissions. At the same time, Denmark also committed to a target of becoming climate neutral by 2050.

The above climate goals have resulted in several proposals for macroeconomic models that attempt to integrate environmental and climate considerations into the economic modelling framework in different ways. The goal of these models is to be able to achieve the climate goals while maximizing economic growth and welfare. The models have therefore most often been used to evaluate different policy proposals. The most frequent proposals put forward through these models are the introduction of so-called carbon taxes. However, the International Monetary Fund (IMF) believes that a broader set of policy initiatives beyond these climate taxes is needed to achieve the objectives put forward. A proposal for such policy measures is given by Krogstrup & Oman (2019)who propose a combination of monetary and fiscal policy measures to achieve the above objectives.

Focusing on the models used, Integrated Assessment Models (IAMs) in particular have formed a large part of the work presented to analyse interactions between climate change and the economy. This type of models, developed by Nordhaus (1992)was quickly adopted by governments and international organisations. In the last few years, however, there has been increasing criticism of the use of these models, both from an academic point of view (Keen, 2021; Pindyck, 2013, 2015; Pollitt, 2019), but also international organisations, which find both theoretical and methodological weaknesses in these models (Feyen et al., 2020).

In addition, there seems to be a lack of expertise among IAM users, where over time disagreements have arisen regarding important aspects of the model type, resulting in sensitive results when simulating these models (Nordhaus 2008, Stern 2007). The case is therefore made for the implementation of a new modelling universe that can integrate a wider dimension of policy actions needed to achieve future objectives.

Focusing on the existing economic models in Denmark, these are not able to measure the effects of different policy measures based on sustainability as well as climate change, as also presented by the Ministry of Finance (Johannesen, 2021). A more recent initiative has been presented for the creation of the Green Reform Model, with a focus on the interaction between environmental change and the Danish economy. The aim of the model is to develop an analytical tool that can be used to make a coherent and consistent assessment of (i) environmental and climate impacts of economic policy, and (ii) socio-economic and business effects of environmental, energy and climate policy (Kirk 2022). It is important to point out here that while there is an interdependence between the macroeconomy and the environment, the Green Reform model only looks at how the economy affects the environment and climate, and therefore does not include feedback mechanisms between changes in the climate/environment and the macroeconomy. In addition, a drawback of the model is its lack of coherence between the financial sector, the real economy, as well as the environment. This can have a major impact on determining the policy measures that can bring Denmark to the goal of the green transition. It is therefore extremely important to use a model that is able to capture these linkages.

# Project proposal

The overall project proposal will work on the same issue as the Green Reform model of integrating environmental and climate elements into an economic model. However, the project will differ significantly on two specific points: i) the choice of model type and ii) the causality between the economy and the 'eco-system'.

The chosen model type is based on the Stock-Flow Consistent (SFC) models, which, in contrast to the previously mentioned Green-Reform model, include a well-defined link between the financial and real sides of the economy, which increases the coherence between the different sides of the economy. The model type thus offers a set-up that links stocks and flows in the economy, through accounting identities and behavioural equations. In the context of the release of the new System of Environmental-Economic Accounting (SEEA) data, the SFC model type appears as an obvious choice to integrate the green transition into a model set-up, as the strong focus on flows and stocks is highly relevant to the whole discussion on emissions (flows) and changes in stocks (temperature changes, amount of CO2 in the atmosphere, etc.) and how this creates feedback to the economic system.

The overall project will be divided into 4 parts, which will eventually end up with a model of the Danish economy that is able to evaluate different policy measures in order to analyze the project research question of *which policy measures enable Denmark to meet the above climate goals without harming economic growth and the living conditions of Danes?*

1. **Building a macroeconomic benchmark model that integrates the environmental dimension**
2. **Building a consistent database for Denmark**
3. **Building an Empirical Stock-Flow Consistent Model**
4. **Durability analyses in the model**

**Part 1 Building a macroeconomic benchmark model integrating the environmental dimension**

In order to be able to examine the link between the economy and the environment, a calibrated benchmark model for a small open economy is set up, which can replicate key elements of the Danish economy. The model is based on the post-Keynesian SFC models and follows the tradition of Espagne et al. (2022), Jackson and Victor (2019) and Jackson (2022). The aim of the model is to identify and model relevant links between the real and financial sides of the economy, as well as the entire ecosystem, in order to be able to examine the evolution of a number of key variables in the short, medium and long term. This provides the opportunity to examine the impact of different policy measures, taking into account the interdependence between the economic cycle and the eco-system. The actual solution of the model involves the development of digital tools that can both simulate the model and examine the impact of different policy measures in the short, medium and long term.

**Part 2 Building a consistent database for Denmark**

The second part of the project includes the construction of a database for the Danish economy, which can be used for the model in part 3 as well as for empirical analyses. The database integrates input-output data with the classical national accounts, the financial national accounts and the new green national accounts in a consistent database. The collection of data itself requires a great deal of knowledge of the data, just as the processing of the data will require a great deal of work, but at the same time provide a unique knowledge of the data. The database will also be open and accessible to other researchers, and include a technical description of the database and its potential to assess combinations of climate policy measures.

**Part 3 Building an Empirical Stock-Flow-Consistent Model:**

This part involves building a model for Denmark based on annual data from Statistics Denmark. The model is intended to include the following four sectors: a private sector, a public sector, the rest of the world, and an environmental sector. This simple set-up will constitute a benchmark model that, in contrast to the IAM models discussed earlier, allows us to analyse how climate policy affects, for example, income distribution in Denmark and other relevant factors that are omitted in the current models. The disaggregated production sector allows the analysis of sector-specific policy measures. The financing of climate policy measures will be more visible here, as the model will include the most needed financial assets in each of the three 'economic' sectors.

The simple structure with only 4 sectors should also make it possible to include feedback effects from climate change on the Danish economy, including rising temperatures, rising sea levels, and increasing chances of natural disasters.   
The properties of the model will allow the execution of several scenarios, each including different climate policy measures, with the aim of finding the most optimal policy measures that achieve the goals of a green transition, without being at the expense of economic or human impacts.

**Part 4: Durability analyses in the model:**

Although several climate challenges are already present, the major climate challenges are still considered to be longer-term. Although many countries, including Denmark, are setting targets to reduce nitrogen emissions (to avoid an escalating effect on the climate), global emissions continue to rise steeply, especially in view of developments in countries such as China and India. Based on the time horizon, it is required that both the baseline evolution of the model and the impact of different actions can be projected many years into the future. Here it is particularly important that we have obtained the correct behavioural relationships that will thus result in realistic economic and climate developments. At the same time, the simple structure of Part 3 will allow the projection of the exogenous variables. The projection will rely on econometric methods as well as machine-learning and deep-learning methods. The econometric methods involve both forecasting using univariate as well as multivariate models. Newer machine-learning and deep-learning methods will also be used where relevant.

# Output

The final output of the project is a PhD thesis, which is expected to be submitted to AAU in 2026. Besides the thesis itself, both the theoretical model (part 1) and the empirical model (part 3) will be attempted to be submitted to relevant journals, and various results will be disseminated through blogs, policy briefs and various working paper series, as this provides a faster dissemination of results compared to research articles. The database developed in part 2 will form the database behind the model in part 3, but will also be made available so that other researchers at AAU or elsewhere can reuse the database to conduct empirical analyses. Finally, the model files associated with both the theoretical and empirical models will be made available so that others can draw inspiration from this work.

The results from each part will be presented at various national and international conferences and workshops, with a view to receiving constructive feedback.

# Background

I am currently finishing my studies as a cand.oecon at Aalborg University. In addition to my time at Aalborg University, I have taken a semester abroad at the University of Wisconsin-Madison.

During my studies at Aalborg University, I have felt an increasing interest in modelling and empirical estimation. The interest in empirical analysis follows from econometrics courses taken at Aalborg University, as well as data science courses under the *Social Data Science* programme, which also provided a foundation for performing forecasts using econometrics, deep-learning, as well as machine-learning. In addition, I have also been introduced to an alternative to the econometric methods taught at Aalborg University, in the form of methods in the field of causal effects taught at the University of Wisconsin Madison. The majority of my semester projects at Aalborg University have involved the use of the above empirical methods.   
 The interest in modelling arose through the two electives: Economic Models I and II, taught at Aalborg University. This led to a bachelor project with the construction of a theoretical SFC model, in order to validate Tobin's portfolio theory in such a model type. Later in my 9. Semester project it also led to work on empirical SFC models, used to evaluate macroeconomic effects of changes in the unemployment benefit program. A short version of this project is expected to be published in ...... As well as the project itself is expected to be published as a working paper in ......

My work as an assistant teacher in the subjects: Mathematics I and II, Statistics, Econometrics II, and Advanced Macroeconomics, has resulted in the development of good presentation and teaching skills, and furthermore given me a better insight into these subjects.